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(54) **ESTABLISHING A UNIQUE SESSION KEY USING A HARDWARE FUNCTIONALITY SCAN**

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(58) **Field of Classification Search**

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See application file for complete search history.

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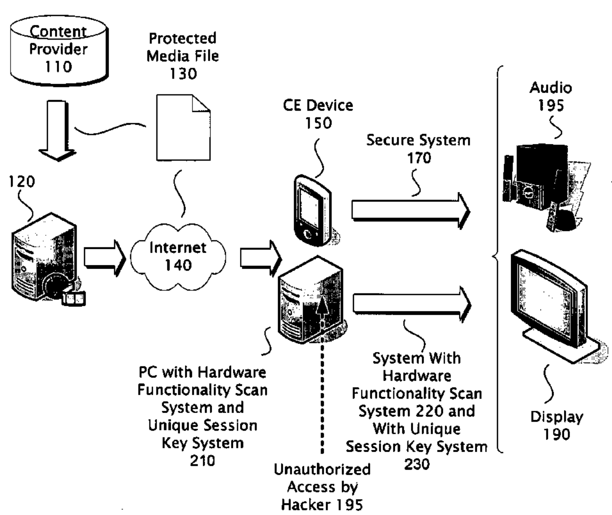
(57) **ABSTRACT**

Systems and methods for independently generating a unique private session key at one or more hardware devices within a computing system using a subset of the functionality implemented in a hardware functionality scan combined with the use of a one-way mathematical function.

20 Claims, 7 Drawing Sheets



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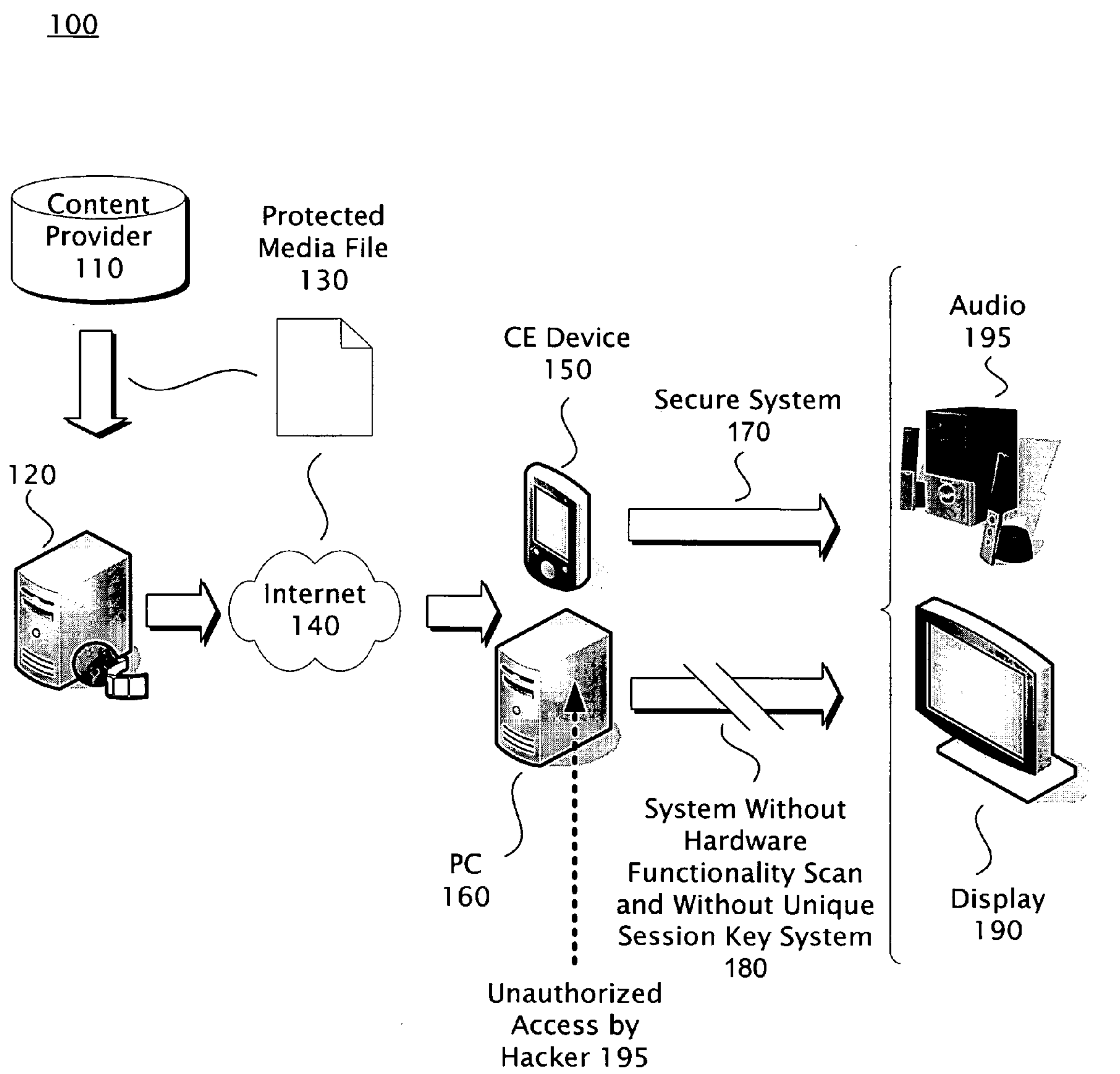

PRIOR ART
FIG. 1

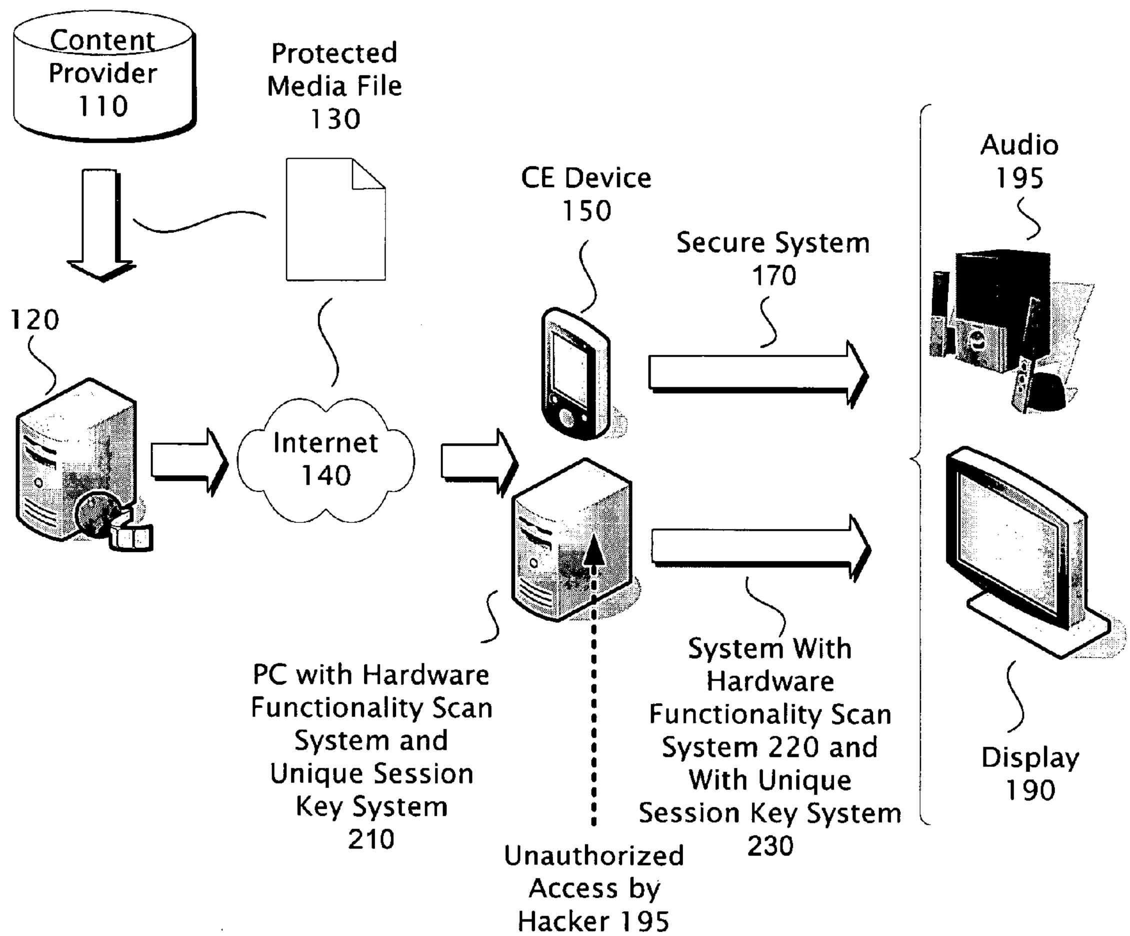
Content Provider 110
Protected Media File 130
120
Internet 140
CE Device 150
Secure System 170
Audio 195
PC with Hardware Functionality Scan System and Unique Session Key System 210
Unauthorized Access by Hacker 195
System With Hardware Functionality Scan System 220 and With Unique Session Key System 230
Display 190

FIG. 2

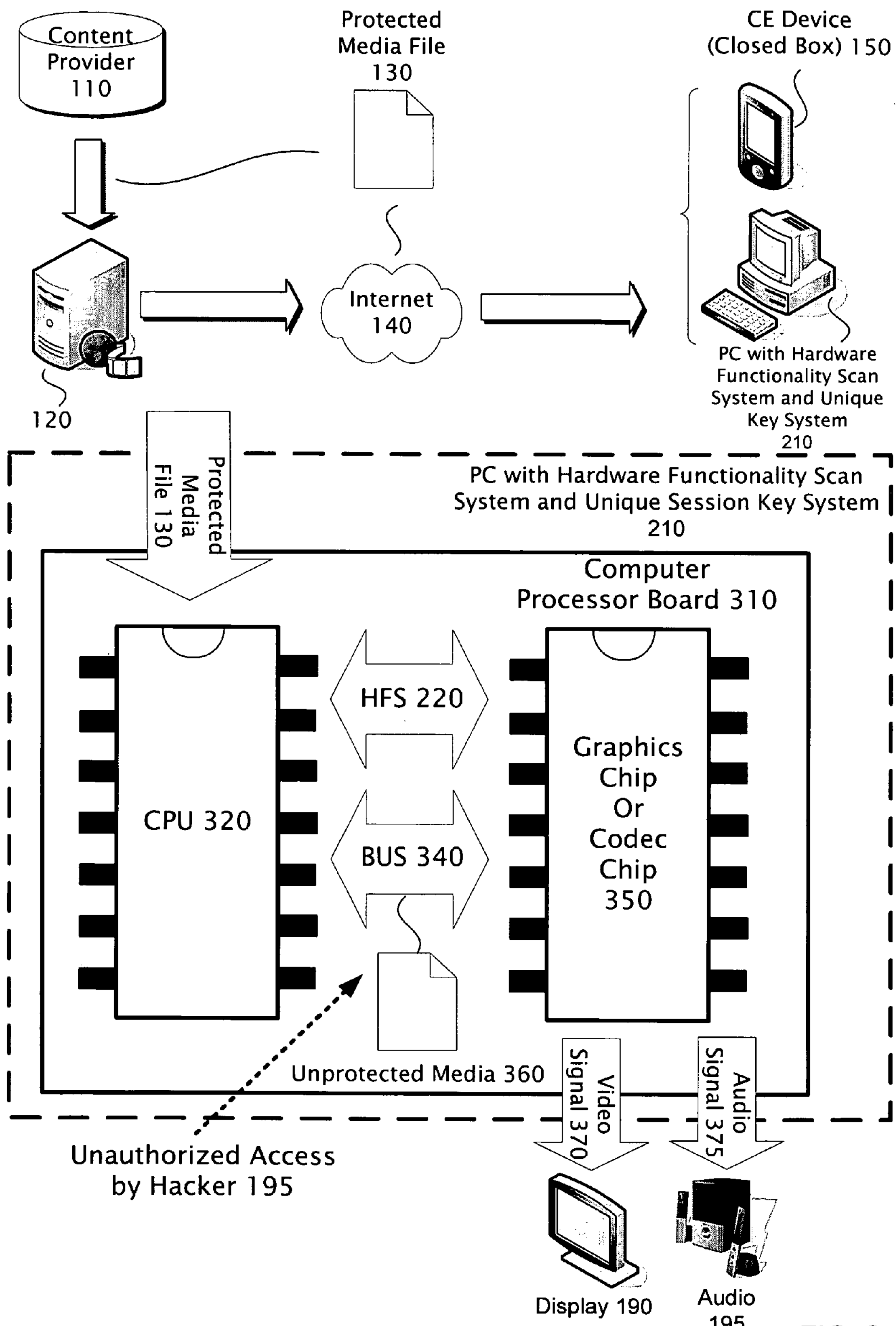
Content Provider 110
Protected Media File 130
CE Device (Closed Box) 150
Internet 140
120
PC with Hardware Functionality Scan System and Unique Key System 210
Protected Media File 130
PC with Hardware Functionality Scan System and Unique Session Key System 210
Computer Processor Board 310
HFS 220
CPU 320
BUS 340
Graphics Chip Or Codec Chip 350
Unprotected Media 360
Video Signal 370
Audio Signal 375
Unauthorized Access by Hacker 195
Display 190
Audio 195

FIG. 3

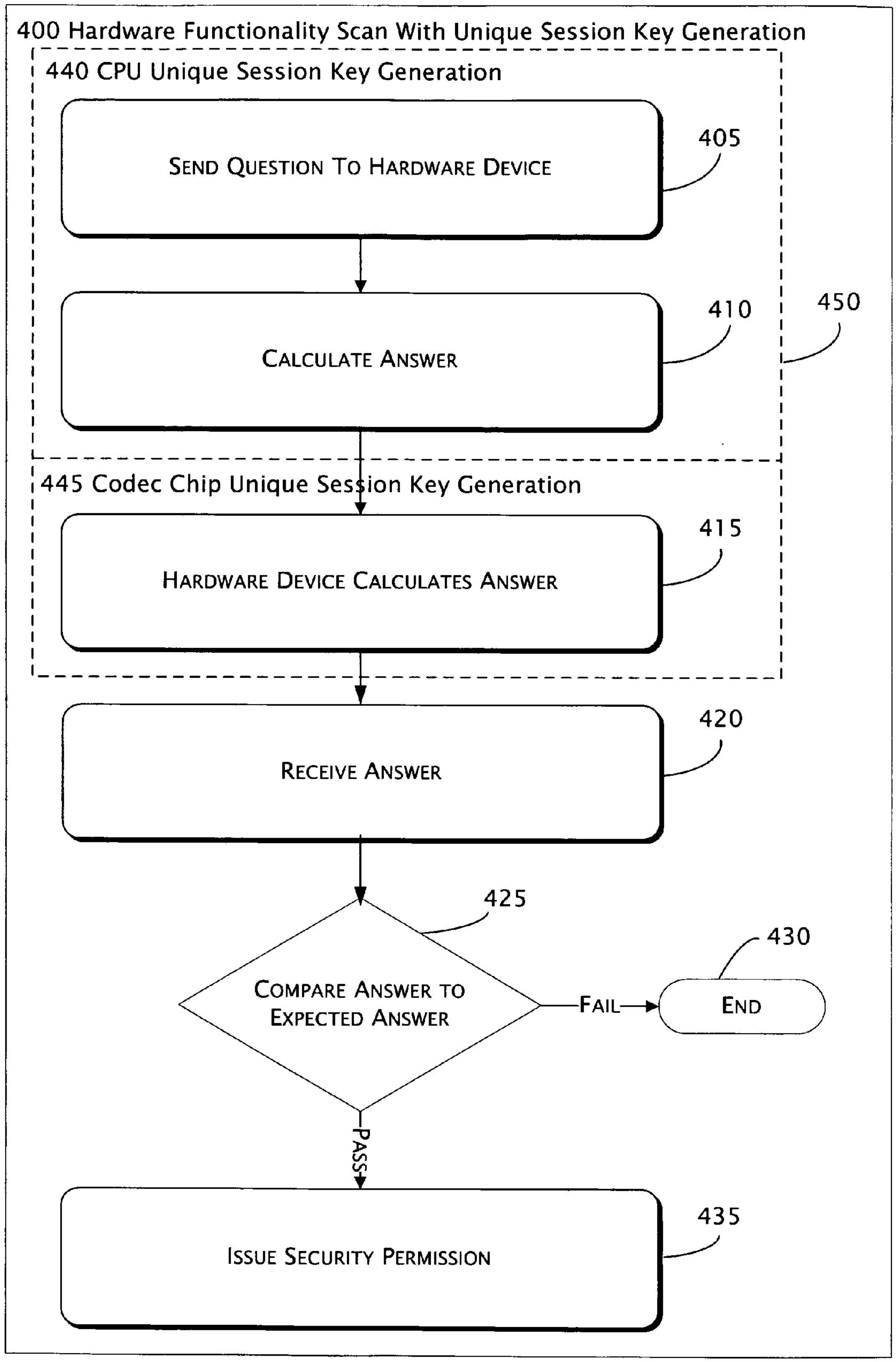
400 Hardware Functionality Scan With Unique Session Key Generation
440 CPU Unique Session Key Generation
Send Question To Hardware Device
405
Calculate Answer
410
450
445 Codec Chip Unique Session Key Generation
Hardware Device Calculates Answer
415
Receive Answer
420
425
Compare Answer to Expected Answer
Fail
End
430
Pass
Issue Security Permission
435

FIG. 4

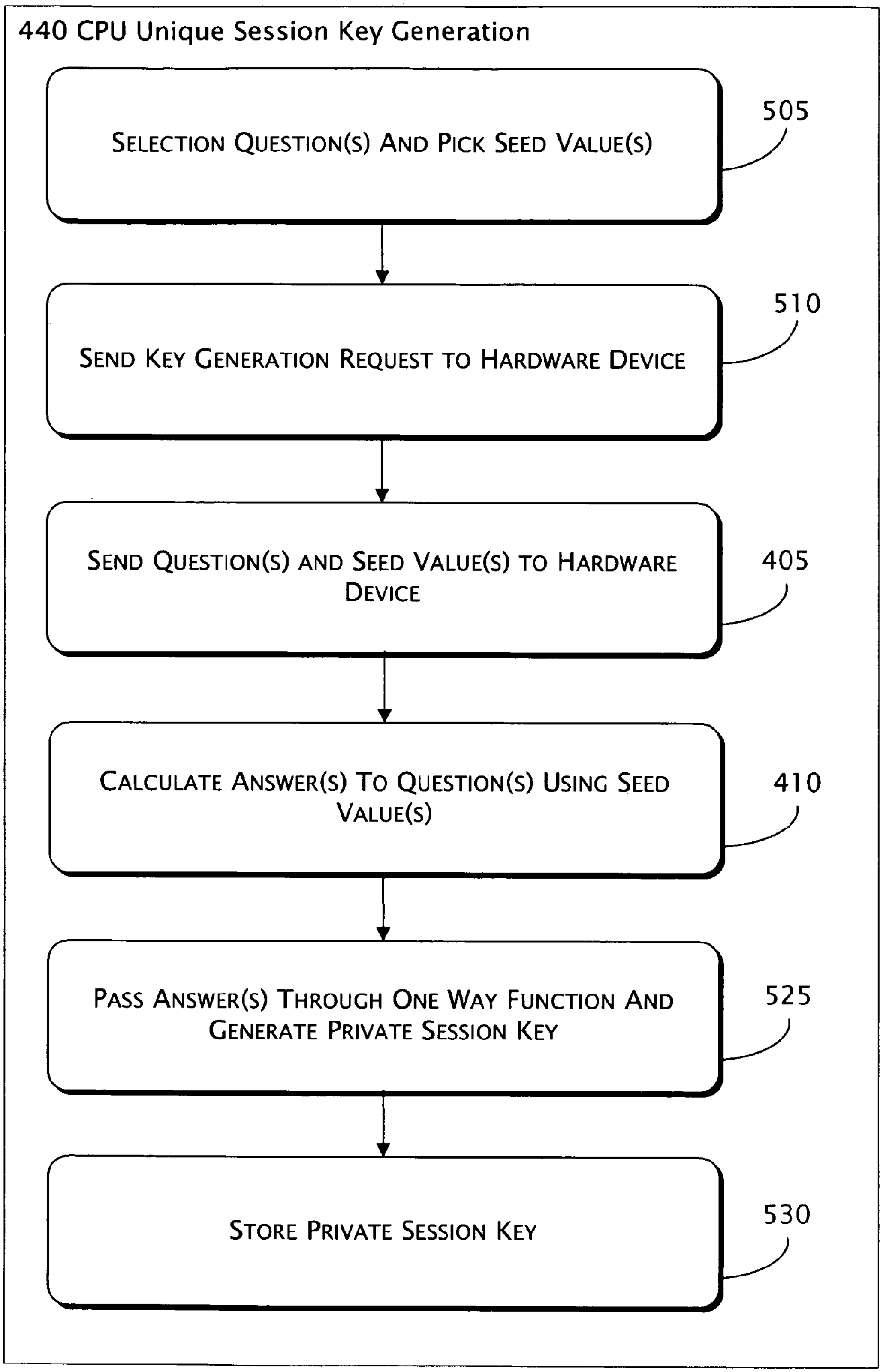
440 CPU Unique Session Key Generation
Selection Question(s) And Pick Seed Value(s)
505
Send Key Generation Request to Hardware Device
510
Send Question(s) and Seed Value(s) to Hardware Device
405
Calculate Answer(s) To Question(s) Using Seed Value(s)
410
Pass Answer(s) Through One Way Function And Generate Private Session Key
525
Store Private Session Key
530

FIG. 5

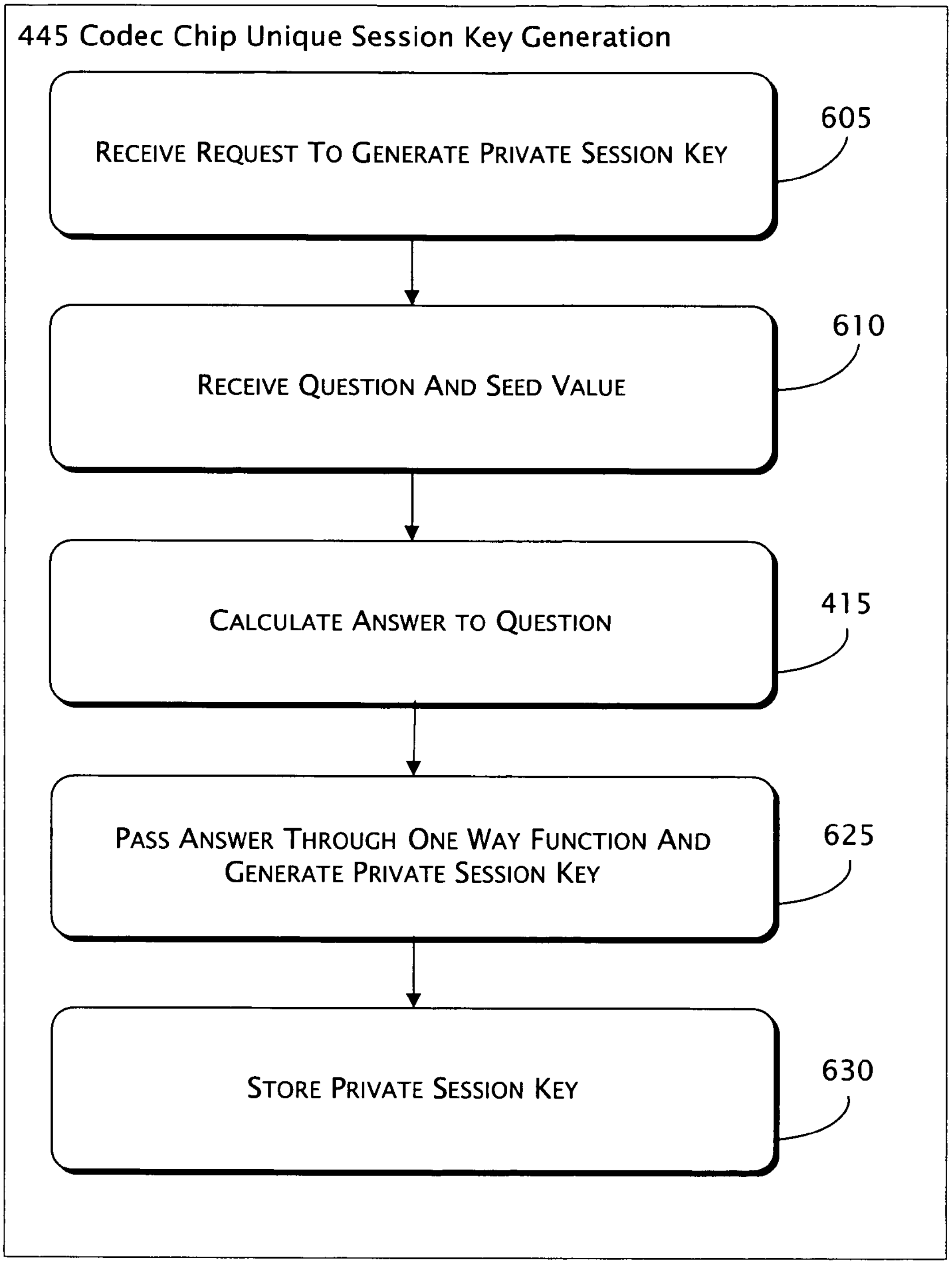
445 Codec Chip Unique Session Key Generation
Receive Request To Generate Private Session Key
605
Receive Question And Seed Value
610
Calculate Answer to Question
415
Pass Answer Through One Way Function And Generate Private Session Key
625
Store Private Session Key
630

FIG. 6

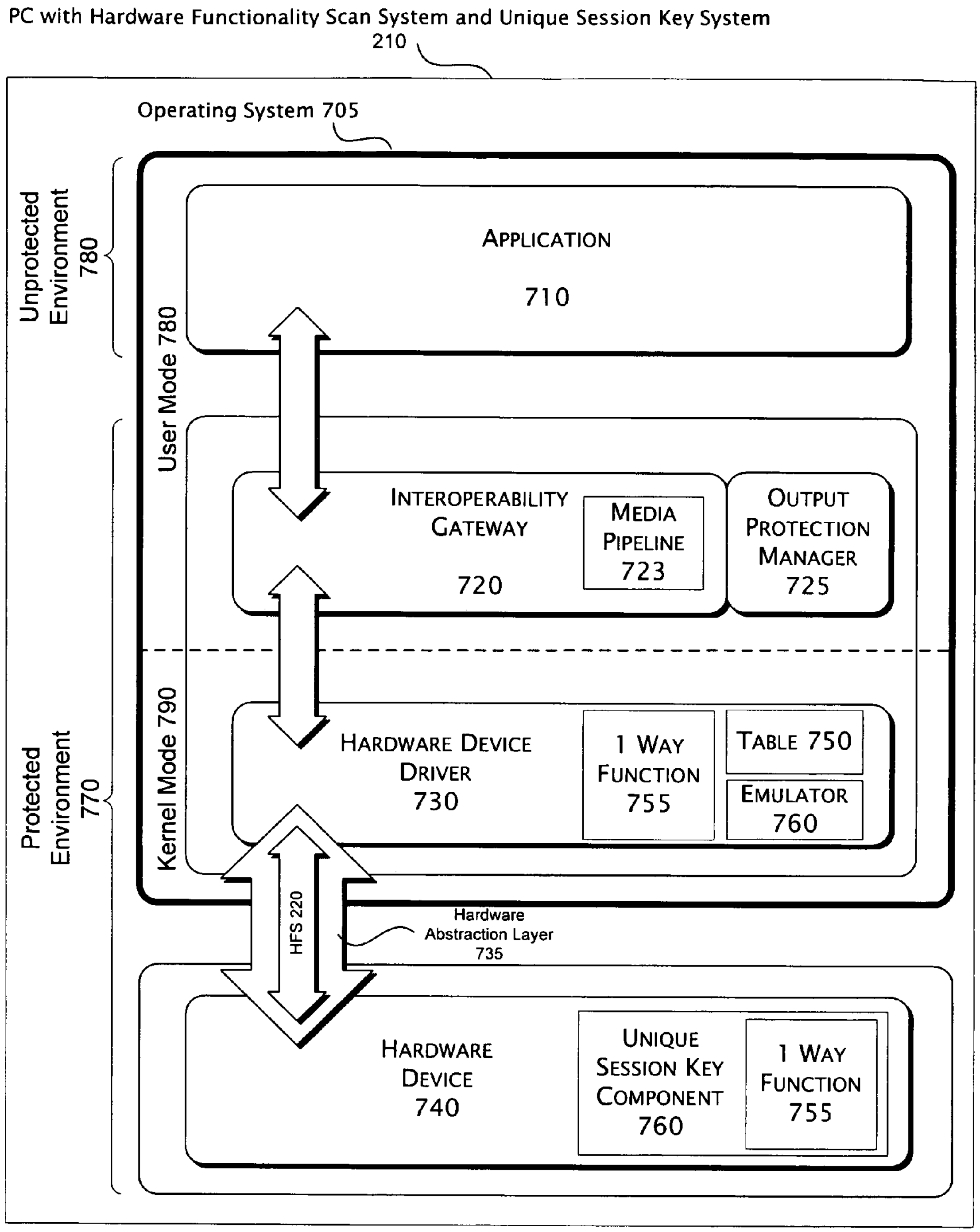
PC with Hardware Functionality Scan System and Unique Session Key System
210
Operating System 705
Unprotected Environment 780
User Mode 780
APPLICATION
710
INTEROPERABILITY GATEWAY
720
MEDIA PIPELINE
723
OUTPUT PROTECTION MANAGER
725
Protected Environment 770
Kernel Mode 790
HARDWARE DEVICE DRIVER
730
1 WAY FUNCTION
755
TABLE 750
EMULATOR
760
HFS 220
Hardware Abstraction Layer
735
HARDWARE DEVICE
740
UNIQUE SESSION KEY COMPONENT
760
1 WAY FUNCTION
755

FIG. 7

ESTABLISHING A UNIQUE SESSION KEY USING A HARDWARE FUNCTIONALITY SCAN

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application No. 60/673,979 filed Apr. 22, 2005, the contents of which are hereby incorporated by reference.

BACKGROUND

This description relates generally to computer security and more specifically to encryption methods and the establishing of private encryption keys in various computer devices for the transmission of digital media and the like.

Such a system may include any number of components that may be coupled by a variety of interfaces that typically seek verification of sufficient security exists before transmitting content. Such systems typically require devices which will play the protected content, to encrypt the protected content such that only a device with an appropriate secret key will be able to decrypt the content. A chain of trust may be used to establish security in such a system. As the use of these systems increases, security tends to become more of a concern due to the increasing transmission of valuable content, and the fact that unauthorized users tend to become more sophisticated in gaining access to protected content.

A provider of high value content or information may wish to ensure that a conventional open computing system such as a PC is secure. A PC and many processor based systems typically present an open system in which hardware components may be easily removed and replaced. Hardware components may include processors, graphics chips, audio codec chips, and the like. Such an open system may present multiple access points for unauthorized access to the content.

DESCRIPTION OF THE DRAWINGS

The present description will be better understood from the following detailed description read in light of the accompanying drawings, wherein:

FIG. **1** is a block diagram showing a conventional PC having conventional security, and a typically secure consumer electronics ("CE") device each without a hardware functionality scan ("HFS") system and without a unique session key system.

FIG. **2** is a block diagram showing a PC with and a CE device with a hardware functionality scan system and with a unique session key system.

FIG. **3** is a block diagram of a computer processor board of a CPU having an HFS system and a unique session key system to generate a unique session key in the CPU and in the graphics device or codec device.

FIG. **4** is a flow diagram showing an exemplary process for performing a hardware functionality scan including unique session key generation implemented by the computer processor board of a CPU.

FIG. **5** is a flow diagram of a CPU generating a unique session key and also sending a request to a hardware device requesting that the hardware device generate a unique session key.

FIG. **6** is a flow diagram showing a response of a hardware device responding to a request to generate a unique session key.

FIG. **7** is a block diagram showing an exemplary computer operating system in which a hardware functionality scan system and/or a unique session key system may be implemented.

Like reference numerals are used to designate like parts in the accompanying drawings.

DETAILED DESCRIPTION

The detailed description provided below in connection with the appended drawings is intended as a description of the present examples and is not intended to represent the only forms in which the present example may be constructed or utilized. The description sets forth the functions of the example and the sequence of steps for constructing and operating the example. However, the same or equivalent functions and sequences may be accomplished by different examples.

Although the present examples are described and illustrated herein as being implemented in a PC based system, the system described is provided as an example and not a limitation. As those skilled in the art will appreciate, the present examples are suitable for application in a variety of different types of computing systems.

FIG. **1** is a block diagram showing a conventional PC **160** having conventional security and a typically physically secure consumer electronics ("CE") device **150** each without a hardware functionality scan ("HFS") system and without a unique session key system **180** that may be used to play a conventional protected media file **130**. Such a PC **160** without a hardware functionality scan system and without a unique session key system **180** may leave the protected media file **130** susceptible to interception by a hacker or another unauthorized party **195**.

The content provider **110** is typically coupled to a media server **120**. The content provider **110** typically places the protected media file **130** on the media server **120**. The protected media file **130** may be created at the media server from content provided by the service provider, or the service provider may provide a protected media file **130** to the media server **120**. The protected media file **130** typically includes audio and visual information or the like. The media server **120** is typically coupled to the internet **140**, and the internet **140** is typically coupled to either a PC **160** or a CE device **150**. The PC **160** or CE device **150** are but two examples of devices that are equipped with a processor. It is specifically contemplated that a variety of devices may equivalently substituted for a PC **160** or CE Device **150**. It is also specifically contemplated that the content provider **110** is not limited in the manner in which the content provider **110** distributes the protected media file **130** to the PC **160** or the CE device **150**. In the following description it will be understood that the term PC may include CE devices, processor board devices, and the like.

A CE device **150** is typically not easy to tamper with because of the fixed configuration of these devices and therefore typically may be considered more secure. In contrast, a PC **160** may typically be easy to tamper with because the hardware of the PC **160** may be more easily accessible and may typically be considered less secure.

The conventional secure system **170** is typically part of a CE Device **150**, the secure system **170** typically includes PC components and methods of protection which may satisfy the content provider **110** that unauthorized access by a hacker **195** may not occur. The conventional secure system **170** may include a CPU, a display **190** which typically renders image information so it may be viewed, and/or an audio device **195** which typically converts digital audio signals to analog signals for play on a conventional audio speaker. Such a conventional secure system **170** may allow playing of protected media file **130** on the display **190** and/or audio device **195**.

In a conventional PC system, the PC **160** is typically coupled to an external display or monitor **190** and/or an audio device **195** using a system without hardware scan functionality and with a unique session key system **180**. The connection between the processor in the CPU and the processor of a graphics device and/or the audio codec device may allow unauthorized access by a hacker **195** at this point. Such a system may typically not allow playing of protected media file **130** on the display **190** and/or audio device **195** because the necessary security elements may not be in place.

FIG. **2** is a block diagram showing a PC **210** with a hardware functionality scan system and with a unique session key system and a CE device **150** without a hardware functionality scan system and without a unique system. The content provider **110** is typically coupled to a media server **120**. The content provider **110** typically places the protected media file **130** on the media server **120** and the protected media file **130** typically includes audio and visual information or the like. The media server **120** is usually coupled to the internet **140**, and the internet **140** is typically coupled to a PC **210**. A CE device **150** may also be coupled to a secure system **170** in the alternative example. The secure system **170** typically includes properties which may satisfy the content provider **110** that unauthorized access by hacker **195** may not occur. In this alternative example, the internet **140** may be typically coupled the CE Device **150**.

The PC **210** may be coupled to a display **190** which typically renders image information so it may be viewed and a set of speakers **195** or other audio equipment which typically allows audio information to be heard. The PC **210** may typically include a hardware functionality scan system **220** and/or a unique session key system **230**.

A hardware functionality scan ("HFS") system **220** may further verify the security permission requested by the content provider **110** to insure that a hacker or other unauthorized party **195** is not accessing an unprotected version of the protected media file **130** at a vulnerable point. A hardware functionality scan is typically performed to verify a security permission on the PC **160**, the security permission typically indicating a proper hardware configuration to prevent unauthorized emulation of the receiving device by hacker **195** in order to access the protected media file **130**.

The HFS system **220** may make use of the complex nature of a hardware device within the HFS system **220** such that the results of a query made up of one or more complex operations may uniquely identify the hardware device when the results of the query returned from the hardware device are analyzed. This analysis may be performed by comparing the results of the query returned by the hardware device to the expected result in a table, or may also be performed by performing an identical query using a software emulation of the hardware device in a secure location and comparing the results of the identical query to the results returned by the hardware device.

A unique session key system **230** may further increase the security of the PC **210** and utilize a portion of a hardware functionality scan to establish a unique session key in any of the hardware devices within the PC **210**. Note that a unique session key may also be referred to as a device key and the two terms may be used interchangeably. The unique session key increases security in the PC **210** because it may be known only to one or more devices communicatively coupled within the unique session key system **230** and may not have been transmitted between the one or more devices communicatively coupled within the unique session key system **230**. The one or more devices communicatively coupled within the unique session key system **230** may then utilize the unique session key to encrypt any information they may wish to exchange. Because the unique session key may not have been transmitted between the one or more devices communicatively coupled within the unique session key system **230**, the unique session key remains private to the one or more devices communicatively coupled within the unique session key system **230** and may be considered a secure unique session key.

The results of the queries discussed above may create a set of identical complex information independently at one or more separate locations within the HFS system **220**. A unique session key system **230** may be implemented to make use of the identical complex information generated independently at one or more separate locations with the HFS system **220** to generate a unique secret session key. The unique session key system **230** may generate a unique session key by passing the results of the query through a one-way function. A one-way function is a cryptographic function well known to those in the art, and may typically be a mathematical function which is easier to compute in a forward direction but is much more difficult to reverse engineer and discover the construction of the one-way function. That is, the one-way function may accept an input and easily create an output, but it may be difficult and may be impossible to generate the input given a particular output. Some examples of a suitable one way function may include the secure hashing algorithm version 1.0 ("SHA1") and the advanced encryption standard ("AES") Davies-Meyer hash function.

The inclusion of a hardware functionality scan system **220**, a unique session key system **230**, or a combination of both a hardware functionality scan system **220** and/or a unique session key system **230** to the PC **160** of FIG. **1** may make the PC **160** as secure as the CE device **150**. That is, the inclusion of a hardware functionality scan system **220** and a unique session key system **230** may make the more open and accessible PC **210** as secure as the closed and inaccessible CE Device **150**.

FIG. **3** is a block diagram of a computer processor board of a PC having an HFS system **220** and a unique session key system **210** to generate a unique session key in the CPU and in the graphics device or codec device. A PC having hardware functionality scan **220** capabilities and/or a unique session key system **230** typically includes a computer processor board **310** which may contain a CPU **320** coupled to a bus **340**. The bus **340** may be coupled in turn to a graphics device or codec device **350**.

The graphics device or codec device **350** may represent a complex integrated circuit ("IC") which may render shapes in unique ways in the case of a graphics device or which may convert a digital audio to an analog signal for play on an audio speaker in the case of an audio codec device. In general, the typical complexity of a graphics device and any unique rendering signatures it possesses may be used to verify that the graphics device or codec device **350** is present instead of an emulation device which may have been put in place by a hacker. Further, the typical complexity of a codec device and any unique decoding signatures it possesses may be used to verify that the graphics device or codec device **350** is present instead of a hacker.

Unauthorized access by a hacker **195** may be attempted through the use of a device emulation that attempts to mimic the real graphics chip or codec chip **350**, and would allow the hacker to access and copy the unprotected media **360**. In such an arrangement the CPU **320** would not have information that anything but a "real" graphics chip or codec chip **350** is present. That is, the CPU **320** may not receive any indication that an emulator is intercepting the unprotected content. However, such an emulator that mimics the real graphics chip or codec chip **350** may not be able to simulate the complexity of the real graphics chip or codec chip **350**, and therefore may not be able to produce the unique rendering signatures or decoding signatures of the real graphics chip or codec chip **350**.

A hardware functionality scan system **220** may make use of a such a lack of the emulator to simulate the complexity of the real graphics chip or codec chip **350** and test such complexity, a failure of such a hardware functionality scan **220** indicating a hacker **195** is present instead of a real graphics chip or codec chip **350**. Thus a device which mimics the real graphics chip or codec chip **350** may not be verified by a system including a hardware functionality scan **220**.

In addition, the content provider **110** may seek to prevent unauthorized copying or viewing of the protected media file **130** by requesting the CPU **320** digitally encrypt protected media file **130** with a key typically kept secret such that it is only known by the CPU **320** and the manufacturer of the graphics chip or codec chip **350**. Such a secret key may satisfy the content provider **110** that the encryption may prevent unauthorized copying or viewing of the protected media file if the secret key is independently derived by the CPU **320** and the graphics chip or codec chip **350**. The independent derivation of the secret key by the CPU **320** and the graphics chip or codec chip **350** may ensure the key is not transmitted across the bus **340**. In an alternative example, unauthorized access by a hacker may be attempted through the discovery of a secret key used to encrypt the protected media file **130** as it passes over the bus **340**. In discovering the secret key used to encrypt the protected media file **130**, a hacker may use the discovered secret key to decrypt the protected media file and make an unauthorized copy of the protected media file **130**.

An example of a Digital Rights Management encryption system is provided in U.S. patent application Ser. No. 09/290,363, filed Apr. 12, 1999, U.S. patent application Ser. Nos. 10/185,527, 10/185,278, and 10/185,511, each filed on Jun. 28, 2002 which are hereby incorporated by reference in its entirety. The authorized PC **210** may use the CPU **320** to decrypt the protected media file **130** and produce unprotected media **360**. The unprotected media **360** is typically passed across the bus **340** in either re-encrypted or unencrypted form to the graphics device or codec chip **350**, which may convert the unprotected media **360** into a video signal **370** which may be displayed by display **190** and/or an audio signal **375** which may be turned into sound waves by audio device **195**.

As previously noted, the unprotected media **360** may be susceptible to unauthorized access by a hacker **195** which may take the form of the hacker or any unauthorized user intercepting the unprotected media **360** on the bus **340**. For example, if the CPU **320** did not encrypt the unprotected media **360**, a hacker may be able to investigate the bus **340** and discover a version of the protected media file **130** which may be ready for play back by the graphics chip or codec chip **350** without any additional processing, which may make the unprotected media **360** easy to copy by a hacker **195** as the unprotected media **360** requires no additional processing for play back.

A content provider **110** who has taken care to protect the delivery of content may also wish to take steps to protect high value content from a hacker **195** and prevent the hacker **195** from making an unauthorized copy in this way. As noted earlier, PC's typically have an open architecture which may make them susceptible to tampering. While a CE Device **150** may be a closed box system wherein it may be difficult for a hacker to replace secure system **170** with a device capable of copying unprotected media **360**, PC **210** is an open box system in which it may be easy for a hacker or any other unauthorized party to either replace a system without a hardware functionality scan system and without a unique session key system **180** with a system which is capable of copying unprotected media **360**. Therefore, before content provider **110** may allow protected media file **130** to be downloaded or streamed to PC **210**, content provider **110** may require that the PC **210** has the hardware authentication afforded by HFS **220** and is coupled to graphics chip or codec chip **350** and not some other capture device which mimics graphics chip or codec chip **350** put in place by a hacker **195** or any unauthorized user. In addition, the content provider **110** may further require a unique session key be established and may require the content be encrypted using the unique session key.

The graphics chip or codec chip **350** may contain a digitally signed certificate which the CPU **320** may typically query in order to verify the authenticity of graphics chip or codec chip **350**. However, due to the properties of the manufacturing process used to create graphics chip or codec chip **350**, it may not be possible to encode such a digitally signed certificate in each graphics chip or codec chip **350**. A hardware functionality scan ("HFS") **220** may not have such manufacturing limitations and therefore, the CPU **320** may perform a hardware functionality scan ("HFS") **220** in order to verify the authenticity of the graphics chip or codec chip **350**.

A hardware functionality scan system **220** may not have such manufacturing limitations as a graphics chip or codec chip **350** is typically a complex device which may be made up of a large number of logic gates across one or more integrated circuits coupled to one another in complex arrangements. A graphics chip or codec chip **350** may also render shapes and other graphical elements in a unique manner in the case of a graphics chip or which may convert a digital audio signal to an analog audio signal for play on an audio speaker in the case of a codec chip. Further, the conversion from a digital audio signal to an analog audio signal which may be performed by the audio codec chip may produce characteristics which may be unique to the specific audio codec chip. The unique manner in which a graphics chip or codec chip **350** may render graphical elements and/or convert a stream of digital audio may be utilized by a CPU **320** to verify that it is coupled to a real graphics device **350** or graphics chip or codec chip **350** and not some other device which mimics the graphics chip or codec chip **350**. The CPU **320** may perform a hardware functionality scan **220** by performing queries to test the unique complex hardware structure of the graphics chip or codec chip **350** such as submitting a shape or other graphical element to the graphics chip or codec chip **350** for rendering and comparing the results of the rendering to an expected result. Typically due to the complexity of the graphics chip or codec chip **350** it is difficult to duplicate or produce by emulation the correct response to the hardware functionality scan **220** by a hacker or another unauthorized party.

To uniquely identify the graphics chip or codec chip **350** the queries or requests of the graphics chip or codec chip **350** may be constructed in such a way that only the specific graphics chip or codec chip **350** may be capable of providing an answer or response that verifies the graphics chip or codec chip **350**. This is typically possible because the graphics chip or codec chip **350** as well as graphics and audio devices in general are composed of a complex arrangement of a large number of gates and have implemented upon them a typically complex state model. Therefore, the same question or request made of two differently manufactured models of graphics and/or audio devices may result in a different answer, or return a different result. An analysis of the answer or returned results may typically identify the specific graphics chip or codec chip **350**.

For example, in the case of a graphics chip, the CPU **320** may send a three dimensional shape to the graphics or codec chip **350** and request the graphics chip or codec chip **350** perform a transformation in three dimensional space, such as shading the three dimensional shape. The graphics chip or codec chip **350** may then send the resulting transformed or rendered three dimensional shape to the CPU **320**. The CPU **320** may examine the returned result to determine if the mathematical representation of the transformed complex three dimensional shape agrees with the results expected by the CPU **320**. Comparisons may be made by consulting a lookup table or a software emulation of the hardware or the like.

In another example, the CPU **320** may have stored a complex mathematical expression. A typical expression would exercise the areas of the graphics chip or codec chip **350** that would typically calculate a unique and known answer for the manufactured model. Further, a typical expression may also include random data, either in the form of agreed upon random parameters to the expression, and/or the expression itself may be chosen at random. For example, a calculated result may have a unique number of digits or a known rounding error that may be exploited. Further, in another example, graphics chip or codec chip **350** may have been manufactured such that additional boundary scan circuitry within the integrated circuits may have been added to verify the functioning of the graphics device **350** in the factory. The boundary scan circuitry may be unique to each model of graphics chip or codec chip **350** and CPU **320** may query the boundary scan circuitry and analyze the results to verify graphics chip or codec chip **350**.

Once the CPU **320** has verified the graphics chip or codec **350**, the CPU may send the unprotected media **360** across the bus **340** so it may be played by the graphics chip or codec chip **350**. However, if the protected media file **360** is not encrypted in some manner, unauthorized access by a hacker **195** may still occur at this point as the hacker **195** may intercept the unencrypted unprotected media file **360** as it passes over the bus **340**. Therefore, content provider **110** may not allow CPU **320** to send the unprotected media file **360** across the bus **340** to the graphics chip or codec chip **350** unless the CPU **320** and the graphics chip or codec chip **350** include some method of encrypting the unprotected media file **360** and decrypting the unprotected media file **360**. Such an encryption method typically involves the use of predefined private encryption keys which are securely included in CPU **320** and graphics chip or codec chip **350**.

However, due to the properties of the manufacturing process used to create graphics chip or codec chip **350**, it may not be possible to include such a private encryption key in each graphics chip or codec chip **350**. As discussed earlier, a hardware functionality scan ("HFS") **220** may not have such manufacturing limitations and therefore, the CPU **320** may perform a hardware functionality scan ("HFS") **220** in order to verify the authenticity of the graphics chip or codec chip **350**. Such a hardware functionality scan **220** may produce an identical set of complex and unique information independently at the CPU **320** and at the graphics chip or codec chip **350**. Such identical complex and unique information may then be passed through a one-way function both by the CPU **320** and the graphics chip or codec chip **350** to create the same session key in both the CPU **320** and the graphics chip or codec chip **350** or any other type of typically complex integrated circuit chip. Note that in order for the session key to remain secure from a hacker **195**, the CPU **320** sends the query however the graphics chip or codec chip **350** does not send a response to the query.

Once the session key has been created, further session keys may be independently created at the CPU **320** and the graphics chip or codec chip **350** and these further session keys may be encrypted and transmitted over the bus **340**. It is also specifically contemplated that other methods of using the complex and unique information generated by a hardware functionality scan **220** to create a unique session key may be equivalently substituted.

FIG. **4** is a flow diagram showing an exemplary process for performing a hardware functionality scan including unique session key generation that may be implemented by the computer processor board of a CPU. The sequence **400** is typically executed on a CPU **320** (of FIG. **3**), but may be executed on any processor.

The exemplary process for performing a hardware functionality scan **400** may include a process for generating a unique session key by a CPU and a codec chip **450** in addition to the hardware functionality scan. Block **450**, which may include blocks **440** and **445**, shows a minimum number of operations that may be used to implement a hardware functionality scan. Other operations may be added in alternative examples to provide unique session key generation and will be further described in the following figures. Note that not all operations performed by the CPU and the codec chip in the process for generating a unique session by a CPU and a codec chip **450** may be performed in the process for performing a hardware functionality scan **400**. Any combination of the operations performed in the process for generating a unique session by a CPU and a codec chip **450** may be performed in the process for performing a hardware functionality scan **400**.

A hardware functionality scan may include unique session key generation to provide a renewable unique session key. Such an addition may tend to increase the security of the system. Such a renewable unique session key process may be implemented by process in the CPU and the codec chip.

The CPU unique session key generation process **440** may be a subset of the exemplary process for performing a hardware functionality scan **400**. The CPU unique session key generation process **440** will be discussed more fully in the detailed discussion for FIG. **5**.

At block **405**, the CPU typically selects and sends a query to the graphics device or codec device in order to verify the authenticity of the graphics device or codec device. As discussed earlier, the query may be constructed in such a way that agreed upon random values are used, and that only the real graphics device or codec device may be capable of providing an answer or response that verifies the graphics device.

At block **410** the CPU calculates the expected result of the query. For example, the CPU may look up the expected result from a stored table corresponding to a table of queries from which the query at block **410** was chosen. In another example, the CPU performs the query using a software emulation of the hardware of the graphics device or audio codec device.

Note that not all operations performed in the CPU unique session key generation process **440** may be performed at this point of the hardware functionality scan process **400**. Any combination of the operations performed in the CPU unique session key generation process **440** may be performed at the point of the hardware functionality scan process **400**.

The codec chip unique session key generation process **445**, which may refer to the process the graphics chip or codec chip performs to generate a unique session key, is also a subset of the exemplary process for performing a hardware functionality scan **400**. The codec chip unique session key generation process **445** will be discussed more fully in the detailed description for FIG. **6**.

At block **415** the graphics device or audio codec device receives the query, then performs the query, then stores the result. The graphics chip or codec chip would then typically send the result back to the CPU for evaluation.

Note that not all operations performed in the codec chip unique session key generation process **445** may be performed at this point of the hardware functionality scan process **400**. Any combination of the operations performed in the codec chip unique session key generation process **445** may be performed at the point of the hardware functionality scan process **400**.

Next at block **420**, the CPU typically receives the results of the query from the graphics chip or audio codec chip. Note the CPU may not need to receive the results of the query to determine if the graphics device is real. A zero-knowledge-proof may be used with the graphics chip or codec chip for the graphics chip or codec chip to prove the graphics chip or codec has calculated the correct result to the query. For example, the graphics chip or codec chip and the CPU may use the result of the query as a key to a follow-on message to the graphics chip or codec chip, and the graphics chip or codec chip may only continue to function if the graphics chip or codec chip produced the expected result to the query, as the graphics chip or codec chip may not have been able to receive the follow-on message which may have allowed the graphics chip or codec chip to continue functioning.

Block **425** may represent an operation to compare the answer received from the graphics chip or codec chip at block **420** with the answer calculated by the CPU at block **410**. Such a comparison may take any form, and the type or design of the comparison operation is not limited in any way. The CPU may then analyze the results of the comparison and determine whether the comparison passed or failed. If the comparison failed the verification may typically end at block **430**.

Terminating the process at block **430** may be the result of the CPU determining the result returned from the graphics chip or codec chip was different from the expected result which may indicate that either an unauthorized graphics chip or codec chip or a hacker is present. The flow of execution typically ends at this point because a security permission may not be issued to the graphics chip or codec chip because the graphics chip or codec chip may not have been validated.

Continuing the process at block **435** may be the result of the CPU determining the result returned from the graphics chip or codec chip was acceptable when compared to the expected result. The secure system may conclude that the graphics chip or codec chip has passed the hardware functionality scan and is an authentic graphics chip or codec chip and not a hacker with an emulation device. The CPU may then issue a security permission on behalf of the graphics chip or codec chip, the security permission indicating that the graphics device has been validated.

FIG. **5** is a flow diagram of a process for a CPU generation of a unique session key. As previously described, a renewable unique session key may utilize a processor and graphics chip or codec chip to provide the process. At block **505**, the CPU may select a query and a seed value, or modifier, for the query. The CPU may select the query at random, according to a set schedule, or using any method. The seed value may also be selected at random, according to set schedule, or using any method. Note that the query may be comprised of multiple queries and multiple seed values and the CPU is not limited in the manner which the CPU may choose the query or queries and the seed value or values.

Continuing to block **510**, the CPU may send an indication to the hardware device which the CPU wishes to generate a unique session key indicating that the hardware device should begin the process of generating a unique session key. Block **405** and **410** function as previously described to provide a hardware functionality scan.

At block **525**, the CPU may implement a one-way function and pass the answer or answers to the query or queries as a parameter or parameters to the one-way function and the result of invoking the one-way function may be a unique session key.

Finally, at block **530**, the CPU may store the unique session key for use in any operation that will require the use of a unique session key, for example, in the creation of a secret encryption key. Once the CPU unique session key generation is complete, the codec chip unique session key may be generated. In an alternative embodiment, the codec chip unique session key may be generated before the CPU unique session key is generated.

FIG. **6** is a flow diagram showing a response of a hardware device, such as an audio codec chip, responding to a request to generate a unique session key. The process shown in this flow diagram augments the previously described hardware functionality scan process. This is accomplished by adding process **605**, **610**, **625**, and **630** which allow renewable unique session keys to be generated by the codec chip.

At block **605**, the hardware device, or codec chip, may receive a request from the CPU to generate a unique session key. Block **605** may be performed in response to the operation performed by the CPU at block **510** (of FIG. **5**). At block **605**, the hardware device or codec chip may discard any earlier created unique session keys or may not have created a secret session key at this point.

At block **610**, the hardware device or audio codec chip may receive a question or questions and a seed value or values. Block **610** may be performed in response to the operation performed by the CPU at block **405** (of FIG. **5**). Block **415** functions as previously described to provide a hardware functionality scan.

Continuing to block **625**, the hardware device or codec chip may implement a one-way function and then pass the answer or answers to the query or queries through such one-way function to generate a unique session key.

Finally at block **630**, the hardware device or codec chip may store the unique session key generated at block **625** and use the private session for any operation which may require the use of the unique session key, for example, the creation of a secret encryption key. As previously described, the blocks may be implemented in various combinations to provide processes that implement a hardware functionality scan with a unique session key generation, a hardware functionality scan, or a unique session key generation.

FIG. **7** is a block diagram showing an exemplary computer operating system in which a hardware functionality scan system and/or a unique session key system may be implemented. Such an environment may allow a hardware functionality scan or a unique session key to be generated by a trusted source.

A PC with a hardware functionality scan system **210** (from FIG. **2**) may typically execute in an operating system **705** to run an application **710**. The application **710** may typically be coupled to an interoperability gateway **720**. The interoperability gateway **720** may be typically coupled to an audio or graphics hardware driver **730**, and in addition, the interoperability gateway **720** may have a secure coupling to the audio or graphics hardware driver **730**. The audio or graphics hardware driver **730** may be typically coupled to a hardware abstraction layer **735**, and the hardware abstraction layer **735** may be coupled to the audio or graphics hardware device **740**.

The operating system **705** may implement a user mode **780** and a kernel mode **790**. The application **710** may typically execute in user mode **780**, and the interoperability gateway **720** also may typically execute in user mode **780**. The hardware driver **730** may typically execute in kernel mode **790**. The operating system **705** may typically implement user mode **780** and kernel mode **790** for security reasons. The operating system **705** may provide user mode **780** with less security permissions than the operating system **705** may provide to kernel mode **790** because kernel mode **790** may have access to elements of the PC **210** which may be more vulnerable to access by hackers. The operating system **705** may not allow components which are not digitally signed and trust to be executed in kernel mode **790**. The operating system **705** may typically provide user mode **780** with less security permissions, and correspondingly less access to the elements of the PC **210** which may be more vulnerable to hackers. The operating system **705** may also typically execute user mode **780** and kernel mode **790** concurrently, and may further execute more than one instance of user mode **780** at once. Security of the kernel mode **790** and user mode **780** may be augmented by providing a protected environment **770**.

That is, the operating system **705** may typically implement an additional layer of security by including differing levels of security execution environments, for example a protected environment **770**. An example of a protected environment is provided in U.S. patent application Ser. No. 11/116,598, filed Apr. 27, 2005 which is hereby incorporated by reference in its entirety.

The operating system **705** may include an unprotected execution environment **780** in addition to the protected execution environment **770**, with the unprotected execution environment **780** including less security permissions than the protected execution environment **770**. The operating system **705** may typically impose a set of security requirements before the operating system **705** which may allow an interoperability gateway **720** or an audio or graphics hardware driver **730** to be either loaded or executed in the protected execution environment **770**. For example, a security requirement may be some form of digital signing or other digital proof of trust. In this manner, the operating system **705** may trust the interoperability gateway **720** or the audio or graphics hardware driver **730** and grant the interoperability gateway **720** or the hardware driver **730** more access to the resources of the PC **210** which the operating system **705** controls. In addition, the operating system **705** may typically implement a smaller set of security requirements before it may allow the application **710** to be loaded or executed, but the operating system **705** may grant the application **710** less access to the resources of the PC **210** which the operating system **705** controls.

Since the audio or graphics hardware driver **730** may execute both in kernel mode **790** and in a protected execution environment **770**, this level of security may be satisfactory to a content provider to authenticate the audio or graphics hardware device **740**. Further, kernel mode **790** may require that the audio or graphics hardware driver **730** be digitally signed and trusted before it may be loaded and executed in kernel mode **790** to offer proof that the audio or graphics hardware driver **730** has been received from a legitimate source. Such proof may be of use in a system of digital rights management ("DRM").

Further, the operating system **705** may implement digital rights management. The content provider trusts DRM and the content provider in turn may require that DRM implements the policy given to DRM for the content. DRM may then verify the content is used with a digitally signed component and if requested that the audio or graphics driver **730** has undergone a hardware functionality scan **220**. The content provider may be satisfied that the audio or graphics hardware driver **730** has authenticated the hardware **740** on behalf of the content provider **110**, and therefore the content provider **110** may be satisfied a hacker has not replaced the real audio or graphics hardware device **740** with an emulation of the audio or graphics hardware device **740** typically to copy the content of the content provider at this vulnerable point. Authentication and content encryption in a DRM system may be augmented by a hardware functionality scan **220** and unique session keys as previously described.

Hardware Functionality Scan

While a real audio or graphics hardware device **740**, for example audio or graphics hardware **740**, may offer protection from copying by implementing security elements which prevent unauthorized copying, a hacker or other unauthorized third party may create an emulation of the audio or graphics hardware device **740** and insert it in the PC **210**. Such a counterfeit hardware device may appear to be the real audio or graphics hardware device **740**, however, a hacker or other unauthorized third party may have constructed the emulated hardware device to report that security features are enabled when the security features are not enabled. In so doing, the audio or graphics device driver **730** may provide a vulnerable version of the information from the content provider **110** to the counterfeit hardware device, and the counterfeit hardware device may freely copy the information.

Accordingly, the operating system **705** may verify that the audio or graphics hardware device **740** is real by using a signed and trusted audio or graphics driver **730**, and requesting the audio or graphics hardware driver **730** perform a hardware functionality scan **220** using the hardware abstraction layer **735**. The hardware functionality scan **220** may determine whether or not the audio or graphics hardware device **740** is a real hardware device and not an emulation put in place by a hacker. Furthermore, to ensure the integrity of Kernel Mode **790** the operating system **705** may verify that all components loaded into to kernel mode and signed and trusted.

The hardware functionality scan **220** is typically a query sent by the audio or graphics hardware driver **730** to the audio or graphics hardware **740**. The query may be written to test the unique complex hardware structure of the audio or graphics hardware device **740**. The audio or graphics hardware device **740** may be a complex device and it may be difficult for an emulation of the audio or graphics hardware device **740** put in place by a hacker to access the protected content to duplicate or produce the correct response. That is, the queries constructed by the audio or graphics hardware driver **730** when performing the hardware functionality scan **220** may be constructed in such a way that the answers to the queries typically uniquely identify the hardware device **740**.

Further, the audio or graphics hardware driver **730** may store a table **750** of queries that it sends to the audio or graphics hardware device **740**. These queries may accept random input data, and the audio or graphics hardware driver **730** may in turn select the input for the query at random. The hardware driver **730** may then compare the answer returned by the audio or graphics hardware **740** to an answer which it expects. Such a comparison may be done directly by requesting the answer from audio or graphics hardware **740** or alternatively may be done indirectly by using the answer in further operations which will only succeed if the audio or graphics hardware **740** has generated the proper answer. If the audio or graphics hardware driver **730** determines the answers are equal, the audio or graphics hardware driver **730** may further determine the audio or graphics hardware device **740** is verified and authentic.

In another example, the audio or graphics hardware driver **730** may implement an emulator **760** of any portion of the audio or graphics hardware **740**. The emulator **760** may be an emulation of the audio or graphics hardware **740** such that the hardware driver **730** may choose a value and perform an operation using the emulator **760**, and then may pass the same value and request to the audio or graphics hardware **740** so the audio or graphics hardware **740** may perform the same operation with the same value. The audio or graphics hardware driver **730** may then verify the results of the operation as performed by the emulator **750** and the audio or graphics hardware **740** to determine the audio or graphics hardware **740** is verified and authentic.

Once the audio or graphics hardware driver **730** has performed the hardware functionality scan **220** and determined the real audio or graphics hardware device **740** is in place, the audio or graphics hardware driver **730** may have performed the function of authenticating and verifying the audio or graphics hardware device **740** and satisfied the trust agreed upon with the content provider as discussed earlier.

Establishing a Unique Session Key

The hardware device driver **730**, which may be an audio or graphics device driver or may be any other complex integrated circuit chip, may encrypt whatever audio and/or visual or data content is sent to the hardware device **740**, which may be an audio or graphics hardware device, in order to further protect the audio and/or visual content from being intercepted and copied by a hacker. The hardware device driver **730** may securely obtain a private encryption key or may make use of an existing private encryption key to encode the audio and/or visual content to be sent to the audio or graphics hardware device for decryption or playback.

However, in order to decrypt the encrypted audio and/or visual content, the hardware device **740** may require the private encryption key be stored within the hardware device **740** in advance at the time of manufacturing. Should this private encryption key become compromised or discovered by a hacker after manufacturing, the key may no longer be useful for encrypting or decrypting the audio and/or visual content as anyone who has discovered the private encryption key may decrypt the audio and/or visual content and use the decrypted audio and/or visual content in any manner they wish.

The current system may not require a private key be included in the hardware device **740** by making use of the unique and complex information which may be generated independently by the hardware device driver **730** and the hardware **740** when a subset of the functionality of a hardware functionality scan **220** is performed. Each of the hardware device driver **730** and the hardware device **740** may utilize the unique and complex information created during the query and answer portion of a hardware functionality scan to produce a unique session key. For example, the hardware device **740** may include a unique session key component **760** which may in turn include a one-way function **755** which corresponds to the one-way function **755** included in the hardware device driver **730**. The unique session key component **760** may send the results of the hardware functionality scan query to the one-way function **755** instead of sending the results of the query back to the device driver **730**.

In order to generate a corresponding unique session key, the hardware device driver **730** may have produced an identical set of complex and unique information in calculating the result of the query. The hardware device driver **730** may also send the results of the query to the one-way function **755** and generate a unique session key. Because each of the hardware device driver **730** and the hardware device **740** have generated a unique session key independently and without exchanging the unique session key, they may now each generate any number of unique keys at any point in time which may not be susceptible to interception by a hacker as the unique session keys may not need to be transmitted.

The unique session key generated independently at the hardware device driver **730** and the hardware device **740** may then be used to further create any number of private encryption keys which may then be used to encrypt audio and/or visual content, or any other type of binary content, at the hardware device driver **730** which may then be decrypted by the hardware device **740**.

If such a private encryption key should be discovered by a hacker, both the hardware device driver **730** and the hardware device **740** may discard the existing unique session key and repeat the process to generate a new unique session key and further use the newly generated unique session key to create a new private encryption key at both the hardware device driver **730** and the hardware device **740**. Such a new private encryption key would not be known by a hacker and content passed from the hardware device driver **730** to the hardware device **740** may be encrypted and protected by the new private encryption key.

Additionally, if the details of the specific hardware functions inside the hardware device **740** should be discovered by a hacker, hardware device driver **730** may be updated and/or enhanced with a new set of queries. The hardware device driver **730** may then be revoked and may be renewed such that the new queries which may be unknown to a hacker may be used to generate a new unique session key.

Those skilled in the art will realize that storage devices utilized to store program instructions can be distributed across a network. For example a remote computer may store an example of the process described as software. A local or terminal computer may access the remote computer and download a part or all of the software to run the program. Alternatively the local computer may download pieces of the software as needed, or distributively process by executing some software instructions at the local terminal and some at the remote computer (or computer network). Those skilled in the art will also realize that by utilizing conventional techniques known to those skilled in the art that all, or a portion of the software instructions may be carried out by a dedicated circuit, such as a DSP, programmable logic array, or the like.

The invention claimed is:

1. One or more computer storage devices having instructions stored thereon that, when executed by a computing device, cause the computing device to perform acts comprising:

in a first instance:

sending a query to a hardware device, the hardware device being one of a plurality of devices associated with a manufacturing model having a common processing signature;

determining an expected result of the query, the expected result reflecting the common processing signature associated with the manufacturing model of the hardware device;

creating, on a processing unit of the computing device, a first session key based on the expected result of the query; and

using the first session key to encrypt or decrypt at least one communication with the hardware device,

wherein the hardware device creates a second session key based on the query by passing an actual result of the query through a function to create the second session key, the second session key being usable to encrypt or decrypt the at least one communication, and

wherein creating the first session key includes passing the expected result of the query through the function used by the hardware device to create the second session key; and

in a second instance:

performing the sending, the determining, and the creating again with a different query to obtain a different expected result and a different session key, and

using the different session key to encrypt or decrypt at least one other communication with the hardware device.

2. The one or more computer storage devices of claim **1**, wherein the expected result and the different expected result are stored in a table.

3. The one or more computer storage devices of claim **2**, wherein the query and the different query are chosen at random from the table.

4. The one or more computer storage devices of claim **2**, wherein the table is obfuscated.

5. The one or more computer storage devices of claim **1**, wherein the expected result and the different expected result are generated using software emulation of the hardware device.

6. The one or more computer storage devices of claim **5**, the acts further comprising:

passing a seed to the software emulation of the hardware device to obtain the expected result, and

passing a different seed to the software emulation of the hardware device to obtain the different expected result.

7. The one or more computer storage devices of claim **5**, wherein the software emulation of the hardware device is obfuscated.

8. The one or more computer storage devices of claim **1**, the acts further comprising performing the sending, the determining, the creating, and the using each time the hardware device is started.

9. The one or more computer storage devices of claim **1**, wherein the second instance occurs when the first session key becomes publicly known.

10. The one or more computer storage devices of claim **1**, wherein the function is a one way function.

11. The one or more computer storage devices of claim **10**, wherein the one way function is a cryptographic hash function.

12. A system, comprising:

a processing unit;

a hardware device configured to perform graphical rendering or audio decoding of data, wherein the graphical rendering or the audio decoding comprises characteristics particular to the hardware device; and

a hardware device driver configured to execute on the processing unit to provide access to the hardware device, the hardware device being coupled to the processing unit via a bus, the hardware device driver further configured to:

provide a query to the hardware device;

determine an expected result of the query, the expected result having characteristics that are expected to be consistent with the characteristics particular to the hardware device; and

execute a first one way function to generate a first session key based on the expected result of the query;

the hardware device being further configured to:

receive the query;

generate an actual result of the query, the actual result having the characteristics particular to the hardware device; and

pass the actual result to a second one way function to generate a second session key,

wherein the first session key and the second session key are usable together to encrypt or decrypt the data, provided the characteristics of the expected result determined by the hardware device driver are consistent with the characteristics of the actual result generated by the hardware device.

13. The system of claim **12**, the hardware device comprising non-volatile storage configured to store the second session key.

14. The system of claim **12**, wherein the hardware device driver executes in a trusted location.

15. The system of claim **12**, further comprising instructions that, when executed by the processing unit, configure the processing unit to revoke and renew the hardware device driver in an instance when the query becomes publicly known.

16. The system of claim **12**, wherein the one way function and the second one way function comprise the same one way function.

17. The system of claim **12**, wherein the first session key and the second session key are identical.

18. The system of claim **12**, further comprising instructions that, when executed by the processing unit, configure the processing unit to:

create additional private encryption keys based on the first session key and the second session key; and

use the additional private encryption keys to directly encrypt or decrypt the data.

19. A method comprising:

sending a query to a hardware device, the hardware device being configured to perform processing for digital to analog conversion of data, the processing having characteristics particular to the hardware device;

identifying a known result of the query, the known result being consistent with the processing characteristics particular to the hardware device;

creating a first session key based on the known result of the query; and

using the first session key to encrypt or decrypt at least one communication with the hardware device,

wherein the hardware device creates a second session key based on the query by passing the second session key through a one-way function to obtain the second session key, the second session key being usable to encrypt or decrypt the at least one communication, and

wherein creating the first session key includes passing the known result of the query through the one-way function used by the hardware device to create the second session key.

20. The method according to claim 19, wherein the hardware device is a graphics device and the processing comprises graphics processing, or the hardware device is an audio codec chip and the processing comprises audio processing.

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